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DIGITAL COMMUNICATIONS UTILIZING MEDIUM VOLTAGE POWER DISTRIBUTION LINES

CROSS REFERENCE TO RELATED APPLICATIONS

1. This application claims priority under 35 U.S.C. § 119(e) from provisional application no. 60/197,615, filed April 14, 2000. The 60/197,615 provisional application is incorporated by reference herein, in its entirety, for all purposes.

INTRODUCTION

2. The present invention relates generally to the field of digital communications. More particularly, the present invention relates to transmission of digital information via power lines.

BACKGROUND OF THE INVENTION

3. Referring to **Fig. 1**, a typical electric power distribution system having half loops **10** is illustrated. These half loops **10** are fed medium voltage (MV) power from the sub station. Medium voltage is in the tens of kilovolts range. A typical configuration has transformers **20** that step MV power down to low voltage (LV) power, low voltage being between 100 and 240 VAC. Each transformer **20** will typically feed LV power to several customers **30**.

4. The half loop **10** uses cable that is either underground, which feeds pad-mounted transformers, or aerial cable, which feeds pole-mounted transformers. The transformers **20** step the MV down to LV. These transformers **20** are designed to work at very low frequencies (50-60 Hz typical) and do not allow high frequencies (greater than 100 KHz) to pass through. Each transformer **20** supplies several homes to the home electric utility meter **32**, which is typically mounted on the outside of the home. Within the home,

concentrated at the breaker panel **34**, a web of electrical wires delivers the power to the outlets **36**.

5. What is needed is a way to use this topology to deliver high-speed communications to residential homes in a cost effective way. Applications for such communication systems include high speed Internet, telephony, video conferencing and video delivery.

SUMMARY OF THE INVENTION

6. It is an object of the present invention to provide high-speed communications via an electrical distribution MV to LV topology.

7. It is another object of the present invention to provide high-speed Internet service via an electrical distribution MV to LV topology.

8. It is yet another object of the present invention to provide telephone and fax service via an electrical distribution MV to LV topology.

9. It is still another object of the present invention to provide video conferencing service via an electrical distribution MV to LV topology.

10. It is a further object of the present invention to provide video delivery via an electrical distribution MV to LV topology.

11. It is a further object of the present invention to provide residential and business security services via an electrical distribution MV to LV topology.

12. The present invention is a means of using the last portion of the electrical distribution system for high-speed communications to residential homes. An aggregation point interfaces a medium voltage power line with a point-of-presence, and a power line bridge enables flow of communications signals between the medium voltage power line and a low voltage power line across a distribution transformer.

BRIEF DESCRIPTION OF THE DRAWING

13. Additional objects and advantages of the present invention will be apparent in the following detailed description read in conjunction with the accompanying drawing figures.

14. Fig. 1 illustrates topology of a typical electric power distribution system.

15. Fig. 2 illustrates topology of an electric distribution system modified to provide for communication, according to an embodiment of the present invention.

16. Fig. 3 illustrates a block diagram of an aggregation point according to an embodiment of the present invention.

17. Fig. 4 illustrates a block diagram of a power line bridge according to an embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

18. According to the present invention, the power delivery system is divided up into three communications channels when configured for high-speed communications:

1. the MV half loop,
2. the LV connection from the transformer to the home, and
3. the wiring within the home.

19. Referring to **Fig. 2**, a modification of the existing power distribution system for communications delivery is illustrated.

20. The first channel (the MV cable) **10** has the least amount of noise and least amount of reflections. This channel has the highest potential bandwidth for communications. This is important because it is the channel that concentrates all of the bandwidth from the other channels. The type of signal used on this channel can be almost any signal used in communications (CDMA, TDMA, FDM, OFDM to name a few). A wideband signal such as CDMA that is relatively flat in the spectral domain is preferred to minimize radiated

interference to other systems while delivering high data rates. The first channel is fed by the AP (Aggregation Point) **110**.

21. Referring to **Fig. 3**, a block diagram of an AP according to an embodiment of the present invention is illustrated. The AP **300** communications to the outside world via the Point Of Presence (POP). The backhaul to the POP can utilize any type of technology, such as optical fiber, copper, or a wireless link. The Backhaul Interface **310** connects the outside world to the MV modem **320**. The MV modem **320** modulates/demodulates the data so that it can be transmitted over the MV cable. The isolator **330** is used as an extra safety measure since the voltages present in the system are relatively high. A preferred isolator structure is based on opto-coupling. The MV coupler **340** is used to prevent the medium voltage power passing from the MV line to the rest of the AP's circuits **310**, **320**, **330**, while allowing the communications signal to pass to/from the AP **300** from/to the MV line.

22. The second channel (the LV connection from the transformer to the home) and the third channel (the wiring within the home) have noise present from electrical appliances and reflections due to the "web" of wires. These channels can support a lower bandwidth than the MV (first) channel and they need a more intelligent (i.e., with more overhead) modulation schemes. There are several companies with chip sets to achieve good communications for LANs (local Area Network) such as: Adaptive Networks (Newton, Mass.), Inari (Draper, Utah), Intellion (Ocala, Fla.), DS2 (Valencia, Spain) and Itran (Beer-Sheva, Israel). These devices would work well for the LV channels.

23. Referring to **Fig. 4**, a block diagram of a Power Line Bridge (PLB) according to an embodiment of the present invention is illustrated. The PLB **400** shown, interfaces

between the MV line on the primary of the transformer and the LV line on the secondary of the transformer. The MV coupler **410** is used to prevent the medium voltage power from passing to the rest of the PLB's circuits yet allowing the communications signal to pass to/from the PLB **400** from/to the MV line. The MV isolator **420** is used as an extra safety measure considering that the voltages present in the system are relatively high. A preferred Isolator **420** structure utilizes opto-coupling. The MV modem **430** modulates/demodulates the data so that it can be transmitted over the MV cable.

24. The data from/to the MV modem **430** is passed to the Data Router **440**. The function of the Data Router **440** is to prioritize and gather packets from all of the LV side devices and pass them on to the MV side. The LV modem **450** modulates/demodulates the data so that it can be transmitted over the LV lines, this function utilizes powerline LAN chip set technology, as mentioned above. The LV isolator **460** and the LV coupler **470** serve the same function as the MV isolator **420** and the MV coupler **410**, but on the LV side.

25. On the LV side of the transformer, the PLB **120** communicates with the Powerline Interface Devices (PLIDs) **136** at the customer location **130**. A PLID **136** can have a variety of interfaces to the subscriber's equipment **138**, **139**. Some examples are RJ-11 Plain Old Telephone Service (POTS), RS-232, USB, and 10 Base-T. A subscriber can have multiple PLIDs **136** on the same internal wiring.

26. A system as disclosed herein is useful to provide data services to the residential market place at 10 Mbps. This makes an entire new range of applications practically available. Each device that is connected to the power would (if desired) have an address and would be accessible remotely. Some examples include remote utility meter reading,

Internet Protocol (IP)-based stereo systems, IP-based video delivery systems, and IP telephony.

27. The present invention has been described in terms of preferred embodiments, however, it will be appreciated that various modifications and improvements may be made to the described embodiments without departing from the scope of the invention.